GROUP TECHNOLOGY

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ABSTRAK

Artikel ini ditujukan untuk meninjau kembali status group technology dan cellular Manufacturing. Tinjauan ini meliputi pembahasan konsep group technolgy, prinsip-prinsip dasar group techology, pembelian pekerjaan pada set manufaktur, keuntungan dan kerugian group techology, dan cellular manufacturing, dan terakhir komentar terhadap status group technology (cellular manufacturing). Meskipun grup techology dan cellular manufacturing memiliki beberapa keunggulan periling, banyak perusahaan terkesari lamban dalam mengadopsi konsep ini, karena beberapa hal: (1) berbagai masalah dan biaya yang timbul daiam melakukan identifikasi, klasifikasi, dan kodifikasi part families, (2) biaya yang timbul dalam menyusun kembali sistem produksi ke dalam sel-sel mesin, serta perlawanan dari pekerja dan manajemen terhadap perubahdti.Untuk memahami dampak dari sistem seluler, evaluasi atas sistem kini dan sistem ssluler yang diusulkan harus dilakukan. Selain itu, perbandingan antara variabel operasional dan karakteristik rancangan fisik harus pula dilakukan.

INTRODUCTION

Because of rapid market technological progress, manufacturers have had to organize flexible, highly productive manufacturing systems. According to Song and Hitomi (1992), in order to overcome difficulties involved in multiproduct, small-lot-sized production, many manufacturing firms are reorganizing the layout of their facilities from a traditional job shop to a cellular shop based on group technology (GT) concepts.

Concept of group technology was first published by Mitrofanov in 1959 and later translated into English (Ghosh, 1990). The first well-documented group technology operation was begun at *Forges et Ateliers de Constructions de Jeument* in

France (Burbidge, 1979, cited by Ghosh, 1990). So far, the general concept of group technology has been practiced under different names within industrial engineering functions for more efficient manufacruring operations. However, it has not been rigorously practiced as a systematic and scientific methodology (Ghosh, 1990). This article aims to review the status of group technology (GT) and cell manufacturing (CM). It includes a presentation of the concept of group technology, the basic principles of group technology, the job shop to manufacturing cells, advantages and disadvantages of group technology (cell manufacturing), and finally, comments on the status of group technology (cell manufacturing).

CONCEPT OF GROUP TECHNOLOGY

The traditional manufacturing approach is to use a line or functional layout based on the product structure of the organization. If the product lines can be manufactured using the same workstations and machines in the same sequence, a line layout is the best choice. For this reason line layout is used in simple process industries or in assemblies where the workload is easy to divide and may be balanced at all stations on the line. In component manufacturing, line layout is used for producing large quantities of a given part, or for producing similar simple parts requiring the same machines in the same sequence (Ghosh, 1990).

Noori (1990) states that where many types of component part are required, batch production is the traditional approach. The standard shop layout for machinery has been functional, based on specialization. Thus department within the shop are formed according to the type of machine and process within the department, e.g. milling, drilling, and grinding.

Organizing the production system based on product specialization has been a major trend in industry. In this system a group of workers specialize in the complete, or near-complete, production of a particular family of parts. This method is known as group technology (GT). Furthermore, group technology is a manufacturing practice that harnesses manufacturing resources for small lot production in much the same way as is done for mass production (Fry, Wilson, and Breen, 1987).

BASIC PRINCIPLES OF GROUP TECHNOLOGY

Group technology requires the formation of. families of parts for which the design and manufacturing processes are similar (Finch and Luebbe, 1995). Machine layout and allocation of resources are then determined accordingly. It is essential that existing equipment be assessed for suitability and, if necessary, appropriate changes made for it (Chase and Aquilano, 1995).

Part Family Formation

The formation of part families is generally the first step in laying the foundation for group technology production. A part family is a group of parts with similar design features such as material or shape, or similar production operations (Ghosh, 1990). According to Song and Hitomi (1992), a number of techniques, both descriptive and analytical, are available for the part family and machine cell formation. Based on conceptual procedures used in forming parts families and machines, Song and Hitomi (1992) have classified the techniques as follows:

1) similarity coefficient (McAuley, 1972; Vakharia and Wemmerlov, 1990; and Askinetal. 1991)
2) machinepart matrix (King, 1980)
3) production flow analysis (Burbridge, 1971)
4) GT concept (Askin and Wiiley, 1984 and Kusiak, 1987)
5) inter-cell flow (Ang and Wiliey, 1984; Seifoddini, 19S9; and Harkhlakis et al, 1990)
6) analytical methods using mathematical tools such as:
   - multivariate analysis (Gorgaware and Ham, 1981)
   - graph theory (Rojagopalan and Batra, 1975 and Kumar etal., 1986)
   - geometry (Robinson and Duckstein, 1986)
   - fuzzy set theory (Ruspini, 1970)
   - mathematical programming (Kusiak, 1987 and Choobineh, 1988).

Furthermore, according to Ghosh (1990), the methods for forming groups are visual, classification and coding, and production flow analysis. Forming groups visually has limitations for assembly processes and process industries. In component processing it is only suitable for a very small range of components.

A classification and coding system provides an effective means for forming part families based on the specific parameters and code digits of the system regardless of the origin or use of the part. Classification is the sorting of parts into groups combining those with similarities based on some predetermined parameters. A code may be a number, letters or a combination which are assigned to the parts for information processing. Coding and classification are the cornerstones of any GT effort, and the most highly developed of implementation steps (Guerrero, 1987).

Many different types of classification and coding systems have been developed and used around the world, for example OP1T2 (Opitz, 1970), KK-I (Hyer and Wemmerlov, 1985), MICLASS (Houtzeel and Schilperoot, 1976) and CODE (Haan, 1977), all cited by Choi and Riggs (1991) and Ghosh (]990). In addition, according to Ghosh (1990), there are several dozens of recognized systems, but many organizations choose to develop their own.

OPITZ system consists of five main digits and four supplementary digits with the possibility of four extended digits (Haan, 1977, cited Choi and Riggs, 1991).The coding system contains part class (1st digit), main shape (2nd digit), the relation of detailed shape of parts and processing by machines (3rd-5th digits), arid the supplementary code for dimensions (6th digit, material (7th digit), original shape of raw materials (8th digit), and tolerance class (9st digit). Choi and Riggs (1991) cite that the OPITZ system is designed to served both process engineering and part design purposes. However, the system's weakness is its universal applicability. Thus, if a manufacturing company specializes in slight modifications to a basic pattern of part design and process engineering, the OPITZ code may not be abie to break down all elements sufficiently to be practical and useful (Shunk, 1976).

Furthermore, Choi and Riggs (1991) add that the Japanese KK-1 system are quite similar to the OPITZ system with larger basic code fields (Ham, Hitomi and Yoshida,1985). The first two digits describe the part's name (function), the 3rd and the 4th digits denote materials, the 5th, 6th, and 7th digits are allocated to express main dimensions, shapes, and ratios of main dimensions, the 8th, 9th, I Oth and 11th digits contain geometrical shapes and machining information, and the 12th andl3th digits describe accuracy and main machining tools respectively.

The MICLASS coding system consists of thirty-two digits. The fist twelve digits contain information about main shape and shape elements (lst-4th), dimensions (5th-8th), tolerance (9th and 10th), and material (11th and 12th) which universally applicable across industries. The remaining digits are designed to code information which is company unique (Chi and Riggs, 1991).

According to Hyer and Wemmerlov (1985, cited by Choi and Riggs, 1991), one well known example' of tailor-made coding and classification systems is the BRiSCH. Since the BRISCH system are tailor-made to each specific user, no two are identical. The first four to six primary digits contain basic design and shape features of all parts. The following secondary digits, variable in length, focus on manufacturing-related information. The BRISCH system codes virtually all types of objects such as raw materials, components, subassemblies, assemblies, tools, portable equipment, machinery, and supporting spare parts; it can generate coding and classification systems that best fit the company's specific purposes, design, and manufacturing conditions.

Layout Planning

Layout planning within the framework of group technology is a vital link for exploiting the benefits of cellular production. Layout planning deals with the analysis of the actual layout, equipment selection, and the creation of GT manufacturing systems. It represents the greatest opportunity for effective manufacturing within cells (Am, i975, cited by Ghosh, 1991).

The first choice in cellular layout is the group technology flow line. Each part of the is should be technologically family should be considered for flow line production. Sufficient capacity and an operation sequence are necessary conditions. In cases where flow line is not practical, the part family should be considered for cellular layout where a consistent sequence of operations is not required. Finally, where part families do not warrant GT cellular layout, a GT center layout should be employed (Ghosh, 1991). Tanner (1985, cited by Ghosh, 1991) lists the following guidelines to aid in the design of manufacturing cells:

(1) There must be sufficient volume of work in the part family to establish a cell. Some families may be too small for configuration of several machines, but they may be ideal candidates for processing on a single machining center.

(2) The makeup of a part family should permit a satisfactory machine utilization

(3) The processe should be technologically compatibel

(4) The required system capacity must be determined from the quantities of parts needed and the production schedule, which determines when they are needed. Problems of balance and machine utilization must be solved.

(5) The physical reorganization of the existing manufacturing systems will require redesign of the production system. This involves the resolution of certain problems: product sign will be affected in terms of new parts and standardization of old parts, and planning and scheduling for the manufacturing system will be different.

In addition, according to Chase and Aquilano (1995), shifting from layout to cellular layout entails three steps:

(1) Grouping parts into families that follow a common sequence of steps. This step requires developing and maintaining a computerized part classification and coding system.

(2) Identifying dominant flow patterns of parts families as bases for location or reallocation of processes.

(3) Physically grouping machines and processes into cells. Often there will be parts that cannot be associated with a family and specialized machinery that cannot be placed in any one cell because of its general use. These unattached parts and machinery are placed in a remainder cell.

Equipment Requirement

The basic benefits of group technology are largely due to the principles of grouping parts and equipment to exploit similarities of parts in families and differences of machines and equipment. However, according to Ghosh (1991), the performance of a GT cellular system can be greatly enchanted if cells formed with existing equipment are scrutinized for additional benefits due to equipment replacement or additions. Ideally, equipment analysis should be carried out in the cell design stage to minimize the number of times cell layouts are changed. There are dozens of factors which indicate that machines and equipment should be replaced or added. Addressing these factors is necessary for a cell to work, and will help the performance of a cell which is working satisfactorily.

FROM JOB SHOP TO MANUFACTURING CELLS

According to Gaither, Frazier and Wei (1990), cellular manufacturing (CT) is a form of production that groups machines, tooling, people and material into manufacturing cells. Each cell produces a family of similar parts, with all parts in the family having nearly the same traits or characteristics, about the same machine setups, and almost same machine routings. CM is not the same as group technology (GT). GT may include CM, but GT is much broader concept.

The Nature of Manufacturing Cells

Some parts within job shops exhibit characteristics that make them good candidates for production in manufacturing cells. Table 2 lists the nature of manufacturing cells (Grayson, 1971; Ham, 1977; Hyer, 1984; and Wemmer-lov, 1989, as cited by Gaither, Frazier, and Wei, 1990).

Table 2. The Nature of Manufacturing Cells

1. Most CM applications are in m fabrication equipment operations.
2. Cells are usually formed by taking production of parts from existing job shop.
3. Parts produced in cells are a relatively small percentage (10%) of the total production. About one-half of the firms report that 5% or less of their machine hours were spent in cells.
4. Both small and large firms use manufacturing cells. Users have from 300 to 17,000 total employees and from 90 to 3,000 machines.
5. Moderate batch sizes of parts are produced in cells: an average of about 6,000 parts per year of each type and a mean batch size of about 750 parts.
6. The number of cells in a CM layout is relatively small. The average is about five or six and about one-third on the firms have three or less.
7. The number of production machines per cell is relatively small. The average is about six and about one-half of the firms have between four and six machines per cell.
8. There are relatively few workers within cells. For manned cells, the range is 2 to 15.

The Characteristics of Parts Appropriate for CM

Similar traits. The similar cylindrical shapes of parts inherent in turning, extrusion, drawing, and other metal-working processes probably explain why most CM applications are in metal-working operations. The general similarity of all part configurations in a metal-working job shop probably improves the likelihood that at least one family of parts can be found such that all parts in the family have very similar physical configurations. There is a close link between the physical configuration of parts and the machine operations that they require in metalworking processes. Therefore, parts with similar physical configurations also tend to use the same type of machines, require similar machine operations, and can be produced with similar tooling and machine settings (Gaither, Frazier and Wei, 1990).

Nature of Part Demand. Although not apparent from Table 1, other factors must also be present for a part to be appropriate for CM. The nature of the demand for a family of parts must also be considered. First, the total demand for a family of parts in a cell must be high enough to provide adequate machine load so that relatively high machine utilization within the cell is achieved. This is particularly important if the overail machine load in the total shop is high; otherwise, new machinery may be needed for the newly formed cells so that the job retains adequate production capacity. Second, the demand for the parts assigned to cells must be relatively stable from period to period. Let us assume that the demand for a particular part within a cell begins to fluctuate greatly, such as going up by a factor of four or drying up altogether (Gaither, Frazier, and Wei, 1990). Under such conditions, parts may need to be transported among the cells and the job shop for processing, or a complete new layout may be required. Thus, the chaos caused from such demand variability is intolerable in CM.

From the above, any job shop that would establish one or more manufacturing cells would need to identify at least one family of parts with these characteristics (Noori and Radford, 1995):

1. The individual parts have such similar traits or characteristics that they can use almost the same machines, similar tooling and similar machine settings.

2. Total demand for the whole family of parts provides adequate loading of the machines in each cell.

3. Demand for each parts family is relatively stable from period to period.

Example of Forming Cells from Job-shop Operations

Figure la and lb show how the partmachine matrix may be rearranged into ceils. The circles in the body of the matrix indicate the machines on which the parts must be produced. For example, Part 1 requires machine operations on Machines A and D. Assign the machines (and the parts that the machines make) to cells such that if a part is assigned to a cell, all of the machines required to make the part are also in the same cell. For example, if Part 1 is assigned to a cell, Machines A and D must also be assigned to that cell.

Figure lb shows a solution to this simple cell formation example. Parts 1 and 3 are to beproduced in Cell 1 on Machines A and D. Parts 2 and 4 are to be produced in Ceil 2 on Machines B, C, and E. Part 5 is exceptional because it can not be produced within a single cell; k requires Machine A, which is in Cell 1, and Machines B, C, and E, which are in Cell 2.

Figure 1a. The part-machine matrix

Machines \ Parts	1	2	3	4	5
A	♦		♦		♦
B		♦		♦	♦
C		♦		♦	♦
D	♦		♦		
E		♦		♦	♦

Figure 1a. The part-machine matrix rearranged into class

Machines \ Parts	1	2	3	4	5
A	♦	♦			♦
D	♦	♦			♦
B			♦	♦	♦
C			♦	♦	
E			♦	♦	♦

ADVANTAGES AND DISADVANTAGES OF GT AND CM

In general, the benefits of group technology (GT) may be classified as follows (Noori; 1990; Ghosh, 1990; Guerrero, 1987; Fry, Wilson, and Breen, 1987; Choi and Riggs, 1991):

1, *Product Design*. The grouping and classification of parts into families makes it easier for a design engineer to determine whether any existing (or slightly modified) products will serve a particular function before a completely new part is designed. In others words, design standardization is promoted.

2. Tooling and Setup. The grouping of machines required to produce particular part families leads to increased standardization of tooling and decreased changeover times.

3. Material Handling. The material handling and movement of parts is reduced relative to traditional process layout plants.

4. Production Scheduling and Process Planning. Production scheduling is simplified, as scheduling must now accommodate only those parts in the family associated with a particular production cell.

5. Lead Times Lead times are reduced through decreased design-to-production time requirements, and through reduced cycle times (a reduction in the actual production time required to produce a part).

6. Capacity The reduction of lead times leads to an increase in manufacturing capacity.

7. inventory The reduction of lead times also leads to a reduction in inventory requirements, especially for work-in-process inventory.

8. Employees Greater employee satisfaction is possible because a small group of employees are now responsible for the production of a part from raw materials to finished product. Along with this, product quality may improve because it will be easer to trace problems back to the source. And since variability of work tasks is reduced, training periods for workers are shortened.

On the other hand, according to Gaither, Frazier, and Wei (1990) and Noori (1990), in general, the disadvantages of GT and CM may be classified roughly as follows;

1. The cost of layout of the job shop and other implementation costs.

2. Major changes to part volume or part mix may cause such things as increased material handling costs from moving parts between cells, changing assignments of parts to cells, and imbalance of work loads among cells. In extreme cases, re-layout may be required,
3. Cost of identifying, classifying, and coding part families.
4. Reduced machine utilization.
5. Capital investment may increase if redundant machines are needed to reduce the transporting of parts between cells.
6. Removing a part from the job shop so that it can be produced in a work cell may make the job shop operate less efficiently. Production costs for parts remaining in the job shop may increase and work load imbalances may be created.

CONCLUSION

The primary drawback in exchanging a traditional process layout for group technology is the loss of flexibility. Since group technology cells are organized around a specific group of components, machines are no longer interchangeable. Thus a reasonably stable product mix is required to ensure an economically viable degree of cell utilization (Eisayed and Boucher (1994).

Although group technology and cellular manufacturing can provide significant advantages, many firms have been slow to adopt the concept for a number of reasons; (1) the problems and costs of identifying, classifying, and coding part families, (2) the cost of rearranging the production system into machine cells, and the general resistance (of both workers and management) associated with any type of change (Noori, 1990).

Most discussions on the GT coding and classification system have dealt with the structural aspects such as the format of the codes, the attributes to be coded, and the applicability of the format and attributes a cross different industries. In spite of the great potential of the coding and classification systems in designing cells, many of the problems in using the format systems for manufacturing cell formation have not been addressed. Procedures for designing cells using coding and classification systems that have been found to be efficient and successful in practice must be identified and reported. Thus, practitioners have to help by reporting their hands-on experiences to improve understanding of this issue (Choi and Riggs, 1991).

To understand the impact of the cellular system, evaluations of both the current system and the proposed ceilular system must be earned out. A comparison of the operating variables and the physical design characteristics of each system must be performed. Operating variables may include: inter-cell traffic intensity, inter-celi traffic intensity, equipment and labor utilization, WIP inventory, queue lengths at each workstation, set-up tome, material handling time, throughput rate, and job lateness. Cellular design considerations include: equipment and tooling investment, equipment relocation cost, floor space requirements, extent of inter-cell material and operator travel, eel! size, flow pattern and flexibility.

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